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(12) UK Patent Application (19) GB (11) 2 084 723 A

(21) Application No **8130006**
(22) Date of filing **5 Oct 1981**
(30) Priority data
(31) **3037594**
(32) **4 Oct 1980**
(33) **Fed. Rep of Germany (DE)**
(43) Application published
15 Apr 1982
(51) **INT CL³**
G01N 21/85
(52) Domestic classification
G1A A3 A4 A6 G1 G2 G6
G9 MH P15 P16 P9 R6 R7
S4 T14 T21 T3 T7 T8 T9
G3R A273 BC29
(56) Documents cited
GB 1579741
GB 1560152
GB 1466766
GB 1152407
(58) Field of search
G1A

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(54) **Controlling a separating device**

(57) A separating device (8) is controlled by continuously scanning the output (13) with a laser (1) to determine a characteristic optical feature thereof and using this characteristic to control one or more variables of the separating device (8). One particle fed onto a wet shaking table (8) at (11) is separated into lighter and darker particles which are collected in chambers (15) and (16). A laser (1) and a photodetector (6) scan the edge of the table by means of a rotating facetted mirror (3), and various operating parameters of the table may be controlled to maintain the desired separation. Alternatively (Figure 2, not shown) the output from a pair of flow cells is monitored by a similar scanning system which controls the supply of chemicals to the cells.

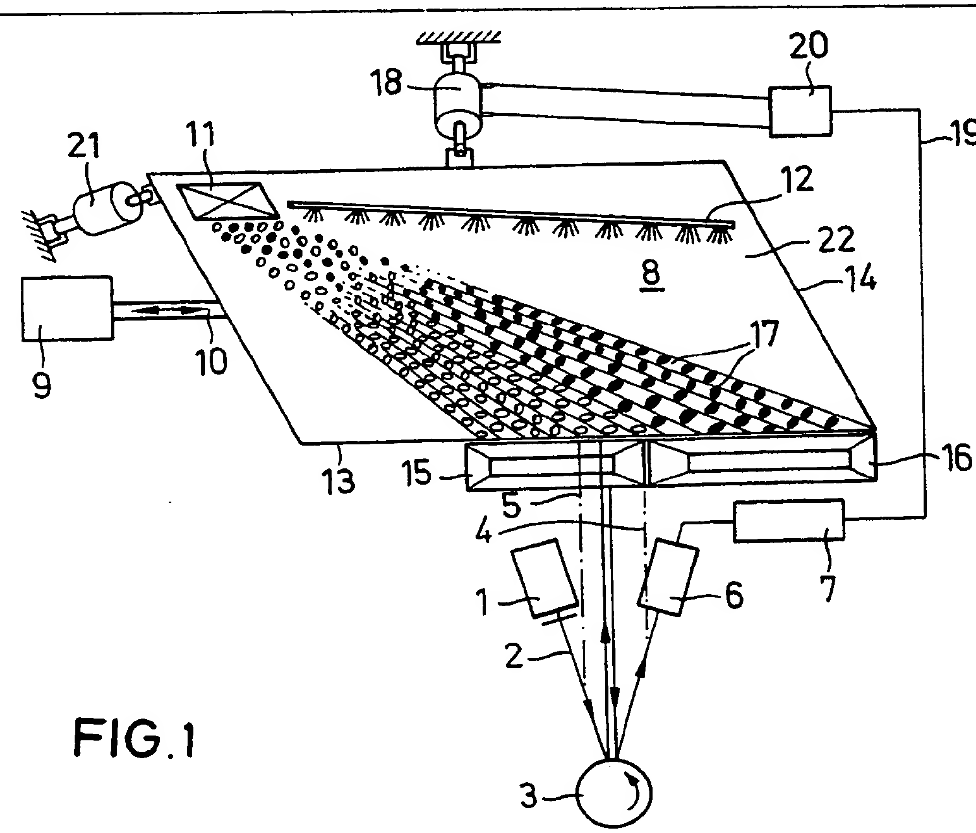

FIG.1

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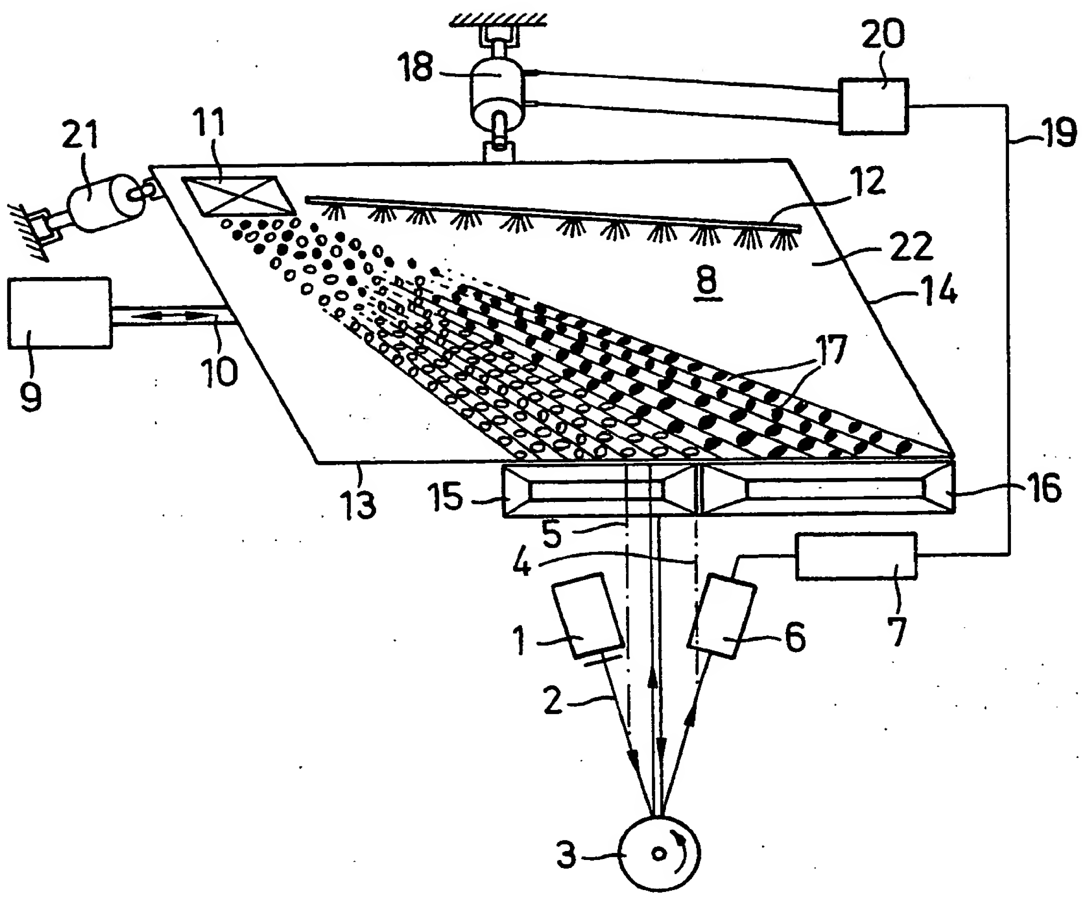

FIG.1

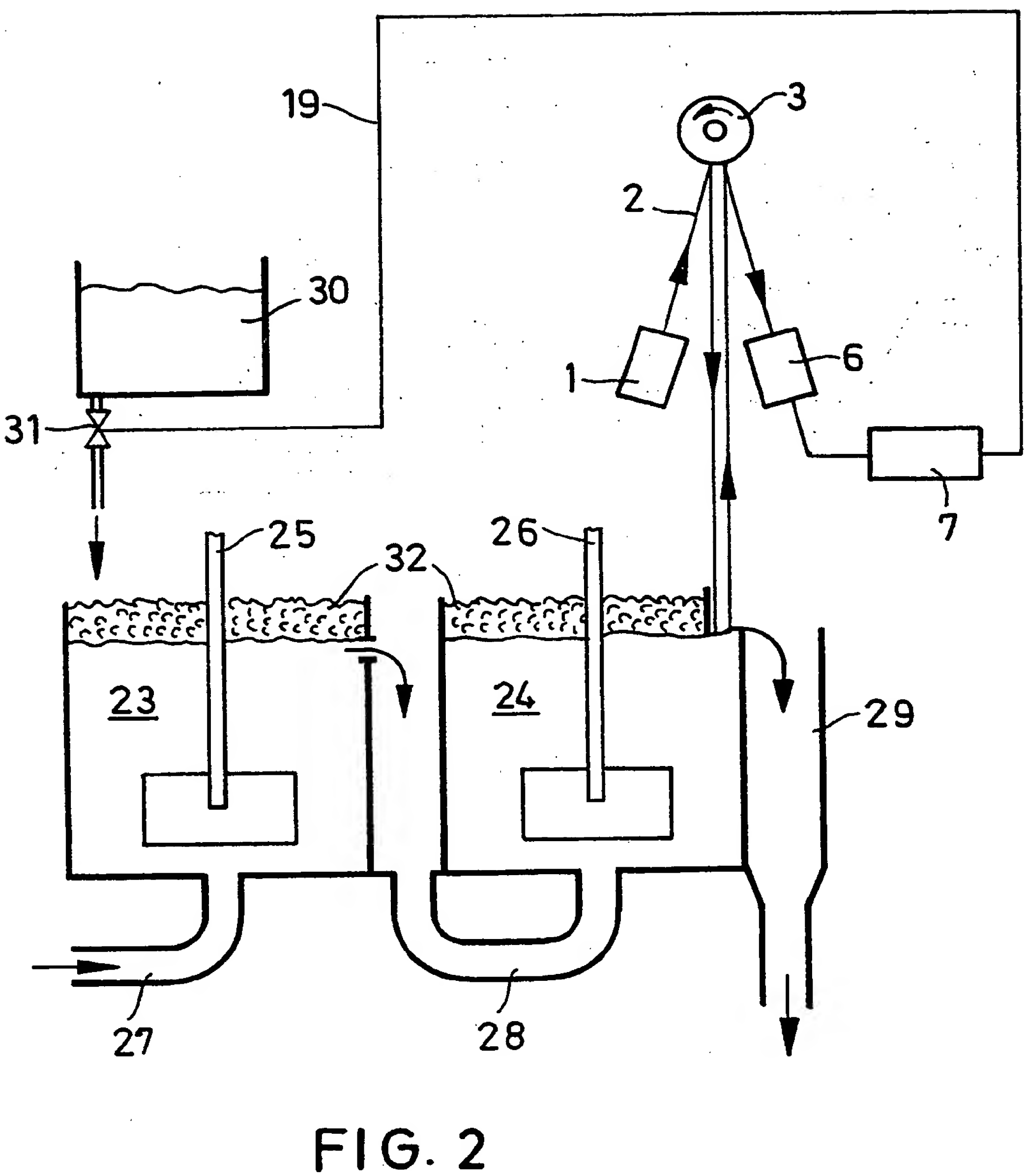

FIG. 2

SPECIFICATION

A method of controlling a sorting device

The invention relates to a method of controlling a sorting device for use in the field of dressing, such as dressing ores or coal.

In dressing technology machines and plant which separate a flow of bulk material, for example pre-classified raw coal or finely ground metal ore into at least two flows of material of different composition are referred to as sorting devices. The pre- condition for this sort of separation is that the materials which are to be separated differ distinctly from each other in at least one physical or physico-chemical property. Known methods of separation can be divided up into those in which the forces used to carry out separation according to physical properties, e.g. gravity or magnetic field, have an effect on the particles to be separated collectively, - this is the case for example with heavy slurry dressing, jigging operations or magnetic separation - and those in which each individual grain is checked for the relevant property and is either kept in the main flow or is removed therefrom. In these methods which sort individual grains as mentioned above, the characteristic properties are usually optical properties in the broader sense, such as colour, fluorescence in the visible range, x-ray fluorescence etc.

This invention relates exclusively to the method which was first mentioned, in which the separating forces have a collective action, whereas they are not based on the method of sorting individual grains which it has been attempted to avoid in industrial practice when dressing mineral raw material and other bulk products, because of the low feed rates and the large cost on apparatus.

In the case of sorting individual grains the use of laser apparatus is already known. Therefore there have been recent developments in which laser beams are used for sorting ores. Preliminary sorting is carried out in order to relieve subsequent crushing plant, the valuable mineral which contains the ore being separated during this preliminary sorting from the valueless rock, while the feed material is broken up into individual pieces of material in the first instance by means of chutes and conveyor belts of different conveyor speeds and these pieces of material are then scanned by an oscillating laser beam. Ore minerals or gangue generally have a different reflection capacity. The corresponding instantaneous reflection values ae intercepted by a photo intensifier and are then processed electronically. One component, either the ore or the barren rock is extracted under computer control by means of a large number of air jets so that sorting takes place. This method is described in detail in the journal "Erzmetall", Volum 31, (1978), pp 16 to 28. The apparatus treated th r makes it possibl to use this new method of sorting individual grains with the aid of lasers, in which the biggest disadvantage is that the quantity of grain which is to be sorted has to be present in a single layer for the sorting process and mor over all of the particles must have been divided up and this requires not only a large technical cost but restricts the throughput per apparatus. Even with collectively acting sorting methods in dressing technology sorting devices are already known such as set tables, flotation apparatuses, jigging machines, or magnetic separators, by means of which quantities of different physical or chemical properties are broken down into their components kand are provided with control devices. Since in these systems the feed material is always a natural raw material, fluctuations in the properties of this feed material cannot be avoided so that the control devices are required in order to match the plant to the ever changing conditions and in this way to achieve the best results. Apart from a few exceptions, this occurs predominantly even today by checking the flows of material extracted from the sorting device using experienced staff and if necessary by adjusting the machine by manual intervention. The method of control may vary considerably depending on the type of sorting machine: in the case of wet tables for example the longitudinal and/or transverse inclination may be varied by lifting cylinders, but the frequency of the stroke or its length can also be varied, in flotation systems and sink/float separators, the height of the overflows for the foam or the floating material can also be varied. Other variable magnitudes are the feed rates for the flows for example. In the case of magnetic separators such as drum separators for example the position of the outlet for magnetisable or the non-magnetisable particles can be affected by rotating the magnetic element inside the drum and can be matched to the properties of the feed material fluctuating in this way or the feed quantity and/or the field strength can be varied. A survey of the most important sorting methods and sorting devices is to be found for example in Winnacker/Kuechler, Chemische Technologie, volume 6, pp 37 ff., Carl Hanser Verlag, Muenchen, 1973.

Again and again attempts have been mde to automate these sorting devices used in dressing raw materials in order to achieve better sorting results which are independent of manual intervention.

This invention seeks to provide a continually operating method for sorting devices of the stated type, this method making the result of the sorting process largely independent of the subjective intervention by the operators and maintains or even increases the usual high throughputs and permits the automatic control of these sorting devices which have not in the past been provided with automatic control devices.

According to the invention, there is provided a method of controlling a sorting device wherein laser beams continuously scan a flow of material from the sorting device to determin a characteristic optical feature of the flow of material and the measur d values d t rmined in this way ar used to control one or mor variables of the sorting device. The use of laser beams or suitable laser-optical systems has the advantage that, thanks to the high intensity of energy of laser beams, it is possible to detect instantaneously and with high accuracy any changes in the optical properties of the material extracted or the various materials extracted from the sorting

devices and to use them whenever necessary to introduce the control process. The very important components of such a laser optical system usually consist of the laser itself, as the radiation source, a deflection system and a photo detector, an electronic evaluation device being connected thereafter. The laser radiation is reflected by the material at the outlet of the sorting device, is intensified and instantaneously processed, certain characteristic optical features of the surfaces of the materials to be sorted being measured and if necessary triggering the automatic process. Since sorting processes are methods of separation and result in at least two separate components of a material then only one of these components or several may be scanned by laser beams, as desired, depending on the number of components.

The method according to the invention may be implemented advantageously so that lasers which can be stepped in wavelength, preferably CO_2 lasers are used. Since the laser beams can be stepped in wavelength, in many cases of practical application, it is possible to adapt the lasers simply to each respective extracted material or to its optical surface properties.

These properties which are to be determined in preliminary tests may, in some cases, result in the use of infra red lasers, in order to achieve optimum results. It is then possible to control even this type of sorting device in accordance with the method of the invention, in which infra red rays provide more easily distinguishable measured values than rays in the visible wavelength range.

Particularly good results may be achieved by using two lasers of different wavelengths. In this case, the technology of differential absorption techniques with laser beams, which is known per se, is applied to the previously unknown measurement of the optical properties of collective flows of material out of the sorting devices. In view of the method used this differential technique provides particularly accurate measured values so that the accuracy of the control processes derived therefrom is correspondingly greater.

This type of scanning is preferably undertaken in the following form: The laser beam or beams scan the flow of material extracted from the sorting device over a restricted line or surface. In many applications it is sufficient to detect the extracted material or the various materials extracted from the sorting device in one plane in order to obtain representative results of measurement for controlling the plant. In order to achieve this, a laser beam can be oscillated in a horizontal plane between two limit lines. This oscillatory movement may also be superimposed by an oscillating motion component perpendicular to the oscillation plane, resulting in surface scanning. Both the lines and the surfaces scanned can be provided for only one extracted material or for several extracted materials. Since not only is a single point used to detect the measured value but rather a variety of points of a line or surface are used in succession, the respective result of measurement which serves to control or automatically control the sorting device ceases to depend on the type of particle of material which has been found at a certain measurem nt point.

In the case of sp cial use of the method according to the invention, brilliance values are determined and processed as a characteristic optical feature of the flow of extracted material. With a number of sorting tasks in dressing technology, the valuable components such as all minerals and coals differ from the worthless component such as gangue or tailings by their brilliance values which can be easily detected with the aid of laser beams and can be distinguished from each other so that there is a characteristic distinguishing feature here which can be used to control the sorting device when processed electronically.

In another sensible practical application of the method according to the invention, there are provided colour values which are determined as a characteristic optical feature of the extracted material. Preferably, this will be implemented wherever there are significant differences in colour in the mineral surfaces between the valuable and valueless components.

In other applications it could be more useful to us the differences in reflection characteristics of the minerals which are to be sorted as the characteristic optical feature. In this case even those materials which only differ in appearance by the fact that one component has a shiny surface and the other a matt surface can also be separated. These sorting processes have up to now been extremely difficult to implement when the plant were only controlled by eye.

Two or even all three of these characteristic features are in practice, frequently present at the same time and are used in combination as distinguishing features.

In those cases in which the brilliance or colour values make it difficult to carry out measurement and control due to reflection at the surface of the materials which are to be sorted, it is preferable to proceed so that the relection from the surface of the extracted material is filtered out by means of polarisation filters in the path or paths of the rays, in order to avoid any distortion of the measurement results.

In any case, when using the method in accordance with the invention the values continuously determined for the characteristic optical feature may be compared to predetermined desired values and the results of these comparisons may be used to fix quantitatively the system variables which are to be corrected. In this way the control circuit does not "resonate" continuously but remains stable within the predetermined and settable limits of the desired values.

The invention will now be described in greater detail by way of example, with reference to the drawings, in which:

Figure 1 shows a schematic arrangment of a laser optical system in conjunction with a wet shaking table

and

Figure 2 shows an arrangement for a flotation apparatus.

A shaking table is one of the least complicated sorting devices and was selected because it is particularly simple to represent in a drawing. The xplained principle of system control in accordance with the invention is not restricted in any way however to an application in tables but rather also applies in other sorting devices such as jigging machines, sinking separators, flotation systems, magnetic separators etc. It can even be used without any difficulty in conjunction with a classifying device, based on the invention disclosed here.

The shaking table 8 comprises a substantially flat plate 22 which if necessary has guide strips 17 which become flatter towards the feed side and which is slightly inclined in a transverse direction and frequently also longitudinally. At one end, the table 8 is connected via a thrust rod 10 to a drive 9 usually implemented as an eccentric element, the said thrust rod 10 moving the table 8 backwards and forwards longitudinally. At the height of the feed point 11 a sprinkler tube 12 is arranged, water being distributed over the whole of the length of the table through this tube. The water rinses the feed material away in the direction of the lower longitudinal edge 13 of the table while the thrust movement gives the particles a movement in the direction of the end face 14 wich is oposite the drive 9. With particles of equal size but different density, the particles of one density will have movement components longitudinally and transversely which are different from the components of particles of another density. These components are determined by the adhesion to the plate 22 on the one hand and by the pressure of the water on the other hand. With dense particles adhesion is the main factor, i.e. a more pronounced component will occur longitudinally on the other hand with less dense particles the transverse components dominate and the particles move transversely. Therefore, the particles lie at the lower longitudinal edge 13 of the table divided up according to their density so that they can be drawn off in the example into two collecting containers 15 and 16, separated according to their density. Similarly, if they have the same density a granular substance can be broken down into grain sizes. In the embodiment which follows it is assumed for the sake of clarity that there are only two types of density but it is not difficult conceptually to convert the ratios for more than two types. With a table of the type described the following can generally be varied:

1. the magnitude of the longitudinal inclination of the table 8 over the stroke cylinder 21
2. the magnitude of the transverse inclination of the table 8 over the stroke cylinder 18
3. the number of strokes of the drive 9
4. the stroke length of the drive 9
5. the height of the guide strips 17
6. the quantity of water in the sprinkler tube 12 per time unit
7. the feed quantity at th feed point 11 per time unit

All of these parameters have an effect on separation when varied and are therefore suitable as variables for carrying out control when this variation is determined and used as a control magnitude for the control path of the sorting device. The laser beam 2 from the radiation source 1 scans the area of the longitudinal edge 13 of the table for this purpose and it is in this edge that the materials which are to be sorted are already separated. This area is detected by means of the rotating facetted mirror 3 for example which makes the laser beam 3 oscillate continuously between two limit lines 4 and 5. Their brilliance values would be used as an example of the characteristic optical distinguishing feature of the materials of different density, in which the specifically heavier material is to have a lower surface brilliance while the less dense material has a greater surface brilliance. The laser optical system is so aligned that the limit line 4 lies in the marginal region in which the interface is between the heavier and darker particles and the particles which are lighter in weight and colour. The radiation returned by the lighter particles is intercepted by the photodetector 6 which converts the brilliance values into electronically processed electrical values such as voltage or current values. These signals are then compared in the electronic evaluation system 7 with preset desired value magnitudes. As soon as the interface between the light and heavy material is displaced over the limit line 4, i.e. increasingly darker particles are being detected by the laser beam, the photocurrent of the photodetector 6 becomes smaller. The control pulse then passes via the electronic system 7 instantaneously via the control line 19 to the control unit 20 which causes the stroke cylinder 18, for example, to decrease the transverse inclination of the table 8. As required the stroke cylinder 18 or some other variable can be adjusted in stages or continuously with or without a time delay either rapidly or slowly or in some other suitable manner.

In Figure 2, two flotation cells 23 and 24 are shown schematically and are charged by means of the slurry inlet 27 or the slurry connection line 28. The agitators 25 and 26 ensures thorough mixing of the slurry with a chemical supplied to the container 30 via the metering valve 31, for example a collector such as xanthate, or a foaming agent such as cresylic acid, and also ensure the necessary introduction of air at the same time. While the flotation concentrate 32 is drawn off from the surface of the cells in a manner not shown, the slurry is drawn off through the outlet 29. The optical properties of the slurry are scanned in a manner which has already been described so that the laser beam 2 emitted by the radiation source 1 is reflected at the rotating facetted mirror 3 and is passed back by the surface of the slurry to the facetted mirror 3 and is then intercepted by the photodetector 6. The measured values are further processed in the electronic evaluation system 7 and any corrections in the addition of chemicals by changing the adjustment of th met ring valve 31 are triggered via the control line 19.

When breaking down the substanc into more than two components, additional laser optical syst ms are prefereably used with separate or a common evaluation device or devices, however it is also possible using a laser beam to scan several regions in succession with the aid of suitable electronic circuits and the results of measurement can then be

processed selectively.

The invention therefore reliably permits automatic control of sorting and/or classifying devices in the manner described. In addition it is not necessary in order to carry out the method in accordance with the invention for the particles which are to be scanned in the plane of measurement and in the area of measurement to be able to be broken down into separate particles and therefore the expenditure which would be required in order to achieve this is eliminated, in fact by contrast it is even advantageous if the particles are tightly packed together because the interference which falsifies the results of measurement are avoided. Sorting devices with large throughputs and high precision can also be controlled to optimum operating conditions.

CLAIMS

1. A method of controlling a sorting device wherein laser beams continuously scan a flow of material from the sorting device to determine a characteristic optical feature of the flow of material and the measured values determined in this way are used to control one or more variables of the sorting device.

2. A method according to claim 1 wherein lasers which can be stepped in wavelength are used.

3. A method according to claim 2, wherein CO_2 lasers are used.

4. A method according to claim 1 wherein infrared lasers are used.

5. A method according to any one of claims 1 to 3, wherein two lasers of different wavel ngths are used.

6. A method according to any one of claims 1 to 4 wherein the laser beam or beams scan the flow of material extracted from the sorting device over a restricted line or surface.

7. A method according to any one of claims 1 to 6, wherein the brilliance values are determined as a characteristic optical feature of the flow of extracted material.

8. A method according to any one of claims 1 to 6, wherein colour values are determined as a characteristic optical feature of the flow of extracted material.

9. A method according to any one of claims 1 to 6, wherein reflection values are determined as a characteristic optical feature of the flow of extracted material.

10. A method according to any one of claims 1 to 8, wherein the reflections of the surface of the extracted material are filtered by means of polarisation filters in the path or paths of the beam or rays.

11. A method according to any one of claims 1 to 10, wherein values continuously determined for the characteristic optical feature are compared to predetermined desired values and the results of this comparison are used to fix quantitatively the system variable(s) which are to be controlled.

12. A method of detecting measured values substantially as described herein with reference to the drawings.

Printed for Her Majesty's Stationery Office, by Croydon Printing Company Limited, Croydon, Surrey, 1982.
Published by The Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.